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INTELLECTUAL VOLTAGE MANAGEMENT IN ELECTRICAL NETWORKS

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MAIN TOPICS

I. Analysis of the current situation of the problems of the voltage regulation in the consumers.Superiority of the Fuzzy sets theory,

II. Main principles of regulation of voltage in the distributive electrical network.
Structural schem and MM of fuzzy-regulation of voltage

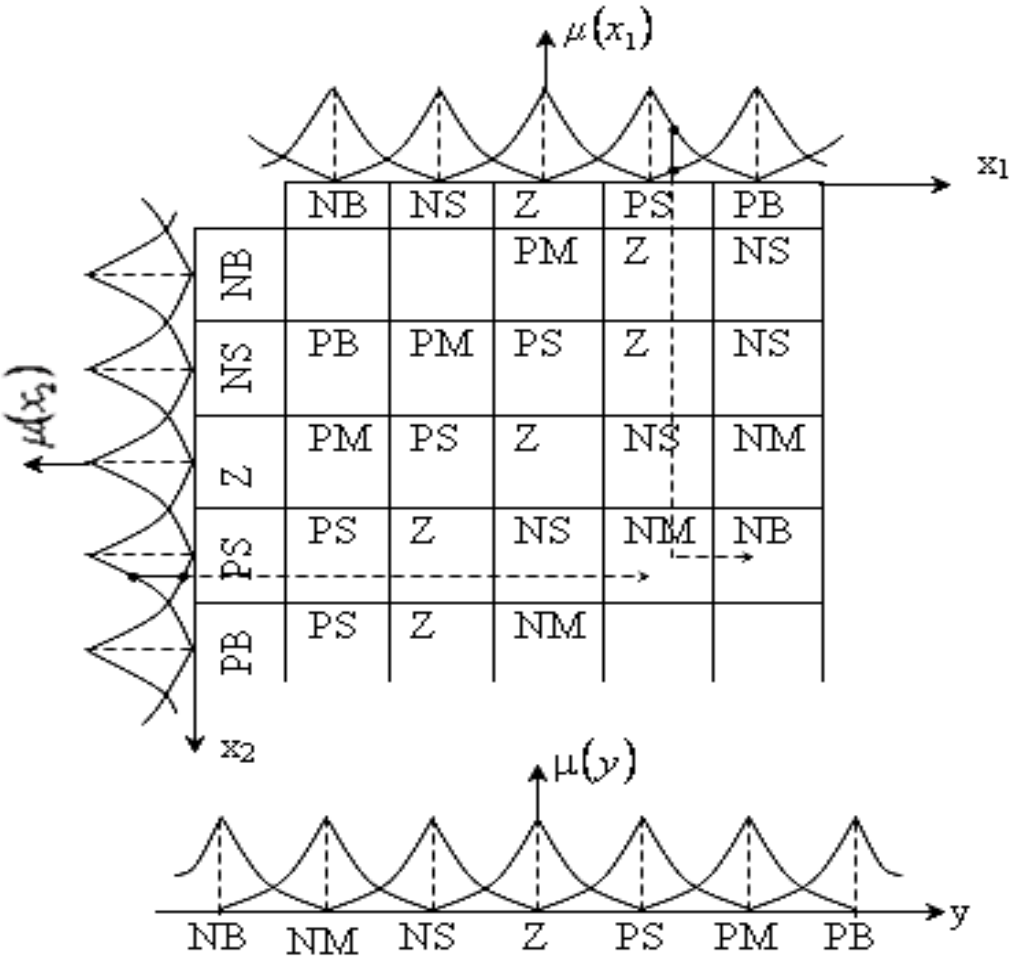
III. The realization of fuzzy-regulation of voltage and the results in distributive electrical networks.

IV. Conclusion

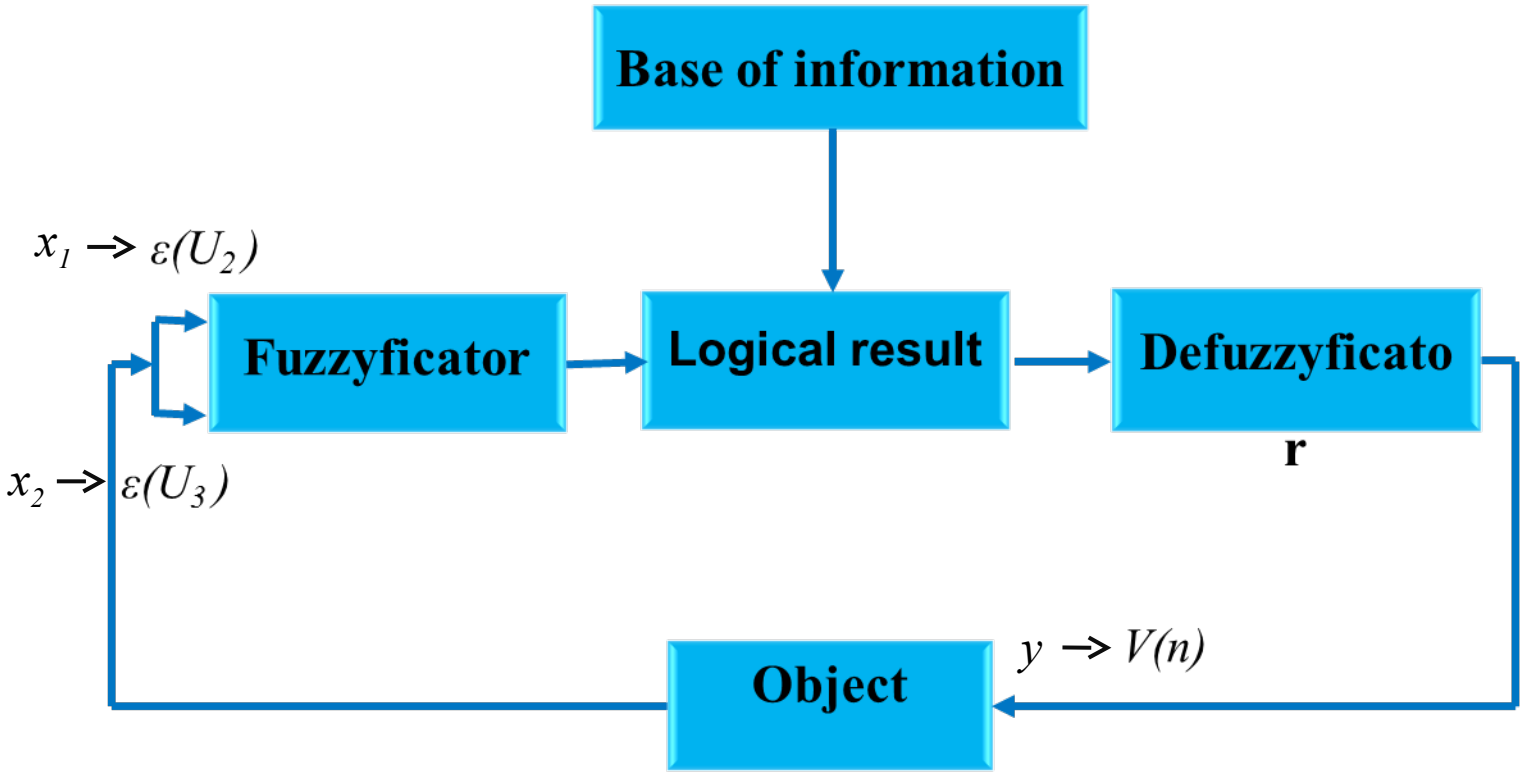
FUZZY-SYSTEM SUPERIORITY

- The possibility of working with fuzzy input data
- The fuzzy formation possibility of evaluation and comparison criteria
- The possibility of carrying out a qualitative assessment of input data and output results
- the possibility of modeling of complex dynamic systems quickly and comparative analysis of it at the rate of given accuracy.

DESCRIPTION OF TWO INTRODUCTORY VARIABLE FAZZY MANAGEMENT ALGORITHM



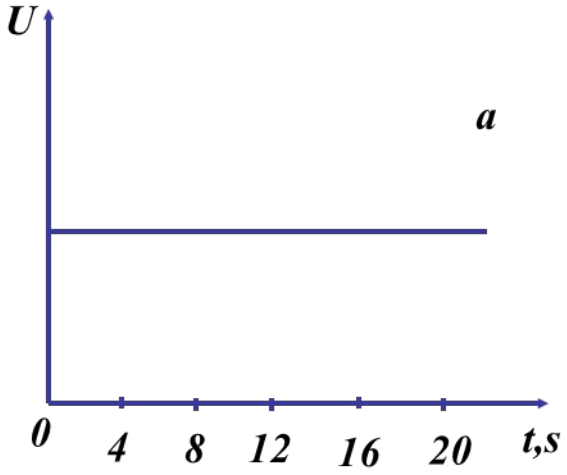
FUZZY MANAGEMENT TOTAL STRUCTURE SCHEME

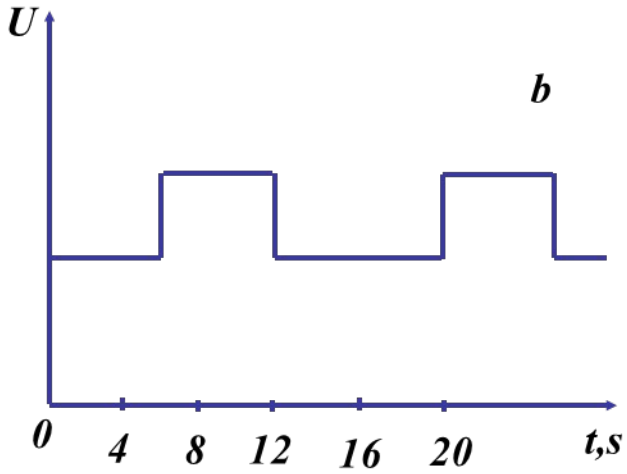


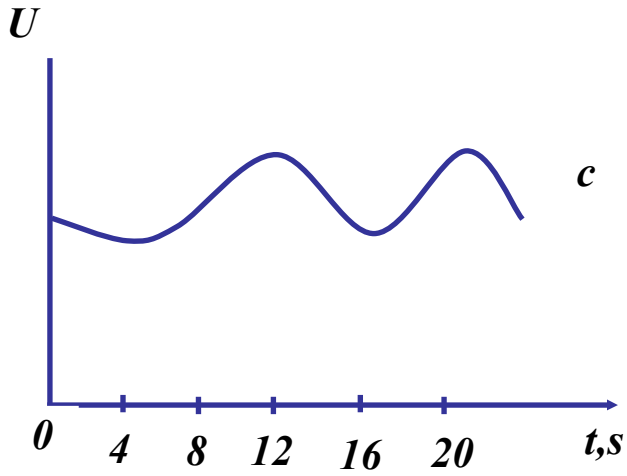
BRIEF SUMMARY OF VOLTAGE CONTROL ON BASE OF FS

- **The application of fuzzy-neural networks in the fuzzy-regulator controlling together with capacitor battery and converter is discussed. In this approach large scale of initial information is needed for the normal operation of controller.** ***(Yuan –Yih Hsu, Feng –Change Lu. A., 1997)***
- **The architecture of fuzzy-controller is researched. The lack of this controller is non-comprehensive work of subject, not noted advantages of new approach.** ***(Kasztenny, B., Rosolowki, E., Izykowski, J., Saha, M.M., Hillstrom, B., 1998)***
- **The assessment possibility of and fuzzy-management application to the voltage regulator on the base of MATLAB program package is studied.** ***(Жмак Е.И., Манусов В.З., 2003)***
- **Different aspects of fuzzy-logic theory application in various fields of Electro energetics are considered. The material is basically in the fuzzy nature and does not consist of any method working of fuzzy-logic application.** ***(Bansal, R.C., 2003)***
- **Logical model has been worked out producing controlling influences by using fuzzy-logic, neural networks and genetic algorithms in order to improve voltage quality in a scale of real time.** ***(Туликов А.Н., 2008)***

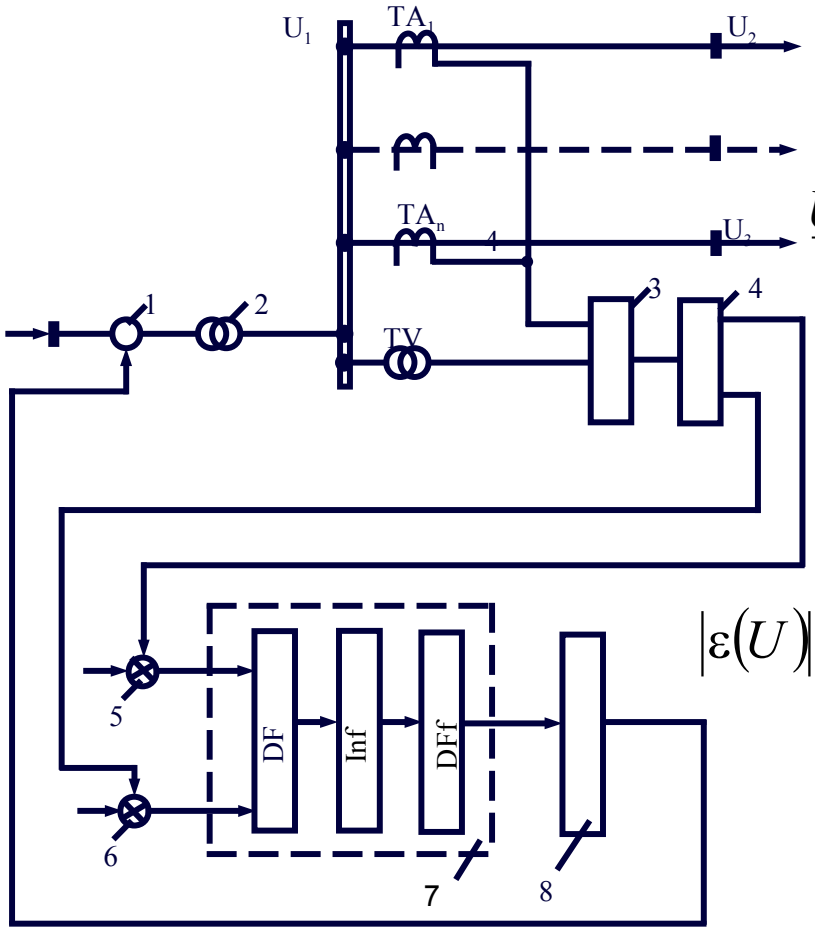
VOLTAGE GRAPHICS OF DIFFERENT MANAGEMENT LAW







DEVICE STRUCTURE SCHEME



$$\dot{U}_2 = \dot{U}_1 - I_3 Z_{L3}$$

$$\dot{U}_3 = \dot{U}_1 - I_4 Z_{L4}$$

$$|\varepsilon(U)| \le \delta \quad (\delta = 4\%)$$

VOLTAGE FUZZY SETS

$E_{11} = NB$	**(negative big)**	$\underset{=}{\Delta}(\varepsilon, \mu_{11}(\varepsilon(U)))$
$E_{12} = NM$	**(negative middle)**	$\underset{=}{\Delta}(\varepsilon, \mu_{12}(\varepsilon(U)))$
$E_{13} = NS$	**(negative small)**	$\underset{=}{\Delta}(\varepsilon, \mu_{13}(\varepsilon(U)))$
$E_{14} = Z$	**(zero)**	$\underset{=}{\Delta}(\varepsilon, \mu_{14}(\varepsilon(U)))$
$E_{15} = PS$	**(positive small)**	$\underset{=}{\Delta}(\varepsilon, \mu_{15}(\varepsilon(U)))$
$E_{16} = PM$	**(positive middle)**	$\underset{=}{\Delta}(\varepsilon, \mu_{16}(\varepsilon(U)))$
$E_{17} = PB$	**(positive big)**	$\underset{=}{\Delta}(\varepsilon, \mu_{17}(\varepsilon(U)))$

In the nearest consumer's buses

$E_{21} = NB$	**(negative big)**	$\underset{=}{\Delta}(\varepsilon, \mu_{21}(\varepsilon(U)))$
$E_{22} = NM$	**(negative middle)**	$\underset{=}{\Delta}(\varepsilon, \mu_{22}(\varepsilon(U)))$
$E_{23} = NS$	**(negative small)**	$\underset{=}{\Delta}(\varepsilon, \mu_{23}(\varepsilon(U)))$
$E_{24} = Z$	**(zero)**	$\underset{=}{\Delta}(\varepsilon, \mu_{24}(\varepsilon(U)))$
$E_{25} = PS$	**(positive small)**	$\underset{=}{\Delta}(\varepsilon, \mu_{25}(\varepsilon(U)))$
$E_{26} = PM$	**(positive middle**	$\underset{=}{\Delta}(\varepsilon, \mu_{26}(\varepsilon(U)))$
$E_{27} = PB$	**(positive big)**	$\underset{=}{\Delta}(\varepsilon, \mu_{27}(\varepsilon(U)))$

In the farthest consumer's buses

$U_{11} = ND$	**(negative direction)**	$\underset{=}{\Delta}(U, \mu_{11}(U(n)))$
$U_{12} = S$	**(stop)**	$\underset{=}{\Delta}(U, \mu_{12}(U(n)))$
$U_{13} = PD$	**(positive direction)**	$\underset{=}{\Delta}(U, \mu_{13}(U(n)))$

The following turning direction of ULTC

MEMBERSHIP FUNCTIONS

$$\left.\begin{aligned}
\mu_{1i}\left(\varepsilon(U)\right) &= \exp\left(-g_{1i}\left|\varepsilon(U)-\bar{\varepsilon}_{1i}\right|\right), && \left(i=\overline{1,7}\right)\\
\mu_{2j}\left(\varepsilon(U)\right) &= \exp\left(-g_{2j}\left|\varepsilon(U)-\bar{\varepsilon}_{2j}\right|\right), && \left(j=\overline{1,7}\right)\\
\mu_{3\gamma}\left(U(n)\right) &= \exp\left(-g_{3\gamma}\left|U(n)-\overline{U}_{1\gamma}\right|\right), && \left(\gamma=\overline{1,3}\right)
\end{aligned}\right\}$$

$$\mu_{1i}\left(\varepsilon(U_2)\right)\geq 0{,}5\Rightarrow\left(\varepsilon(U_2)\right)\in E_{1i}$$

$$\mu_{2j}\left(\varepsilon(U_3)\right)\geq 0{,}5\Rightarrow\left(\varepsilon(U_3)\right)\in E_{2j}$$

$$\mu_{3\gamma}\left(U(n\ )\right)\geq 0{,}5\Rightarrow\left(U(n)\right)\in U_{1\gamma}$$

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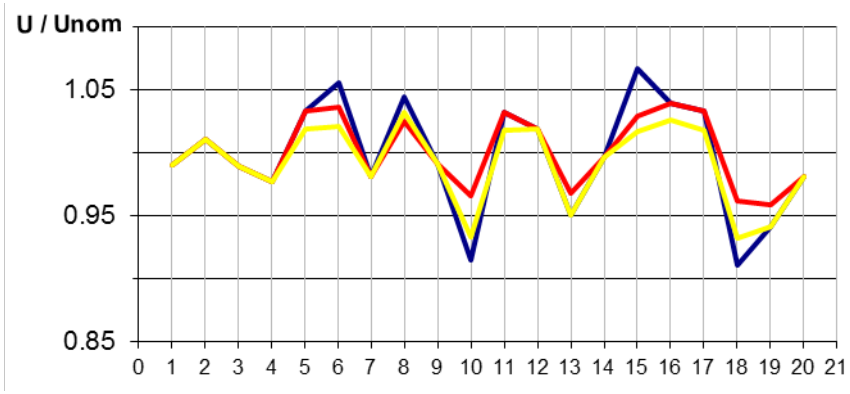
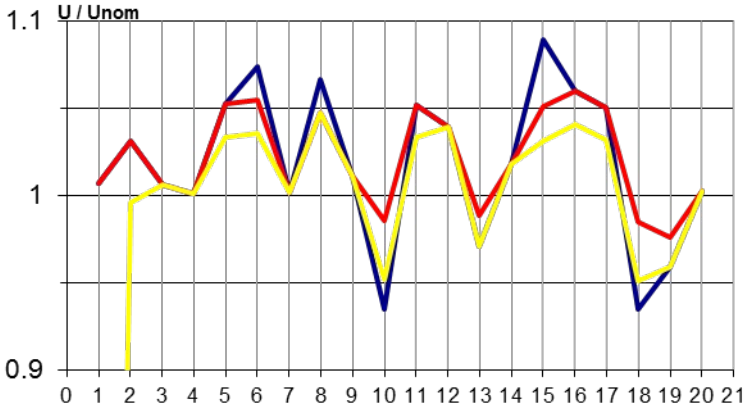
LINGUISTIC RULES TABLE FOR FUZZY-REGULATOR

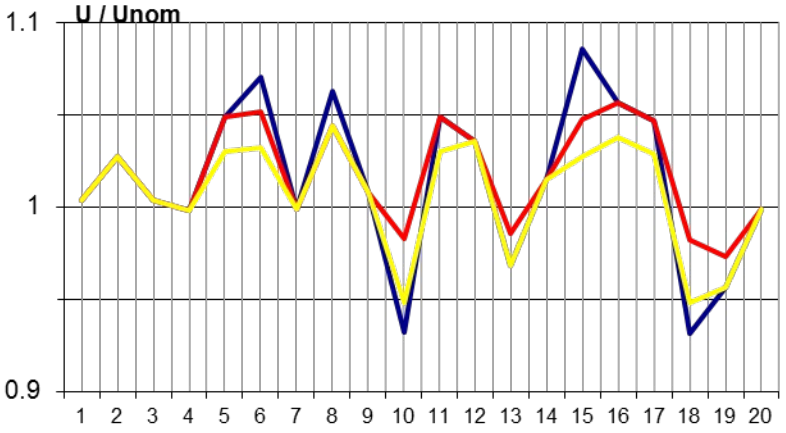
	NB	NM	NS	Z	PS	PM	PB
NB	PD	PD	PD	PD	PD	ST	ST
NM	PD	PD	PD	PD	PD	ST	ST
NS	PD	PD	PD	ST	ST	ND	ND
Z	PD	PD	ST	ST	ST	ND	ND
PS	ST	ST	ST	ST	ST	ND	ND
PM	ST	ST	ST	ST	ND	ND	ND
PB	ST	ST	ST	ST	ND	ND	ND

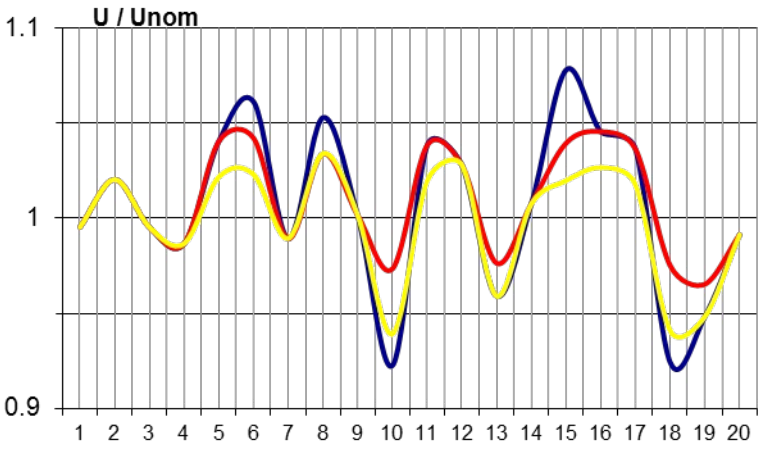
VOLTAGE CURVES IN SUPPLUIED & CONSUMERS BUSES



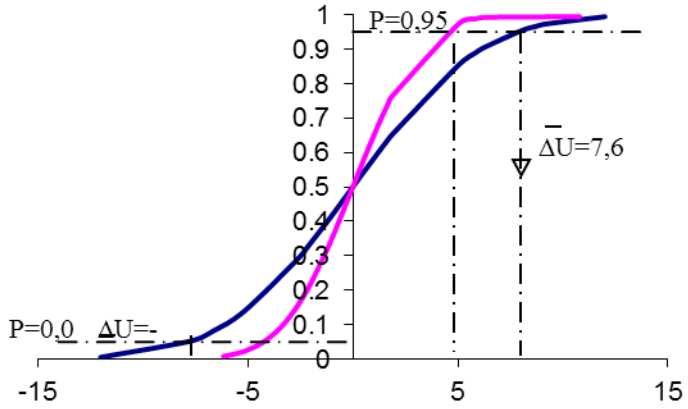


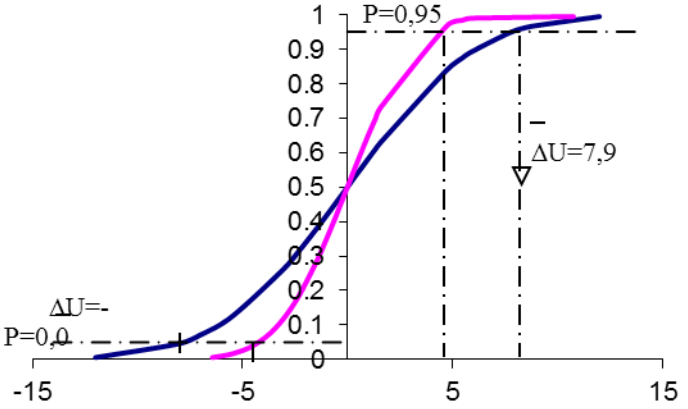
Before control After fuzzy control After traditional control

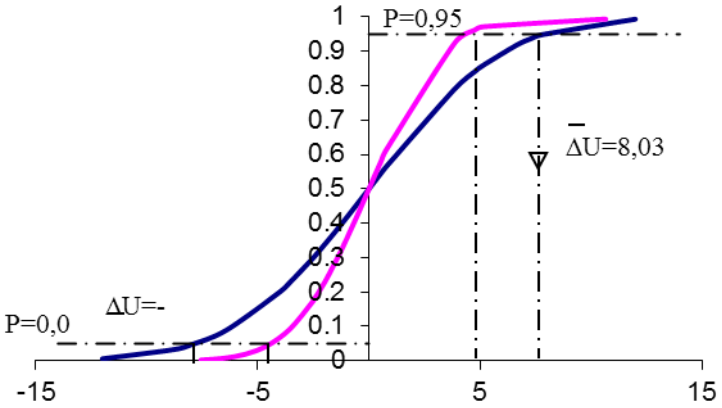


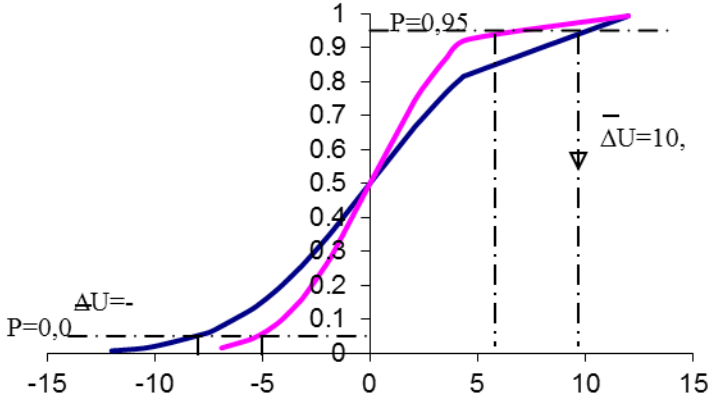


VOLTAGE DISTRIBUTION FUNCTIONS





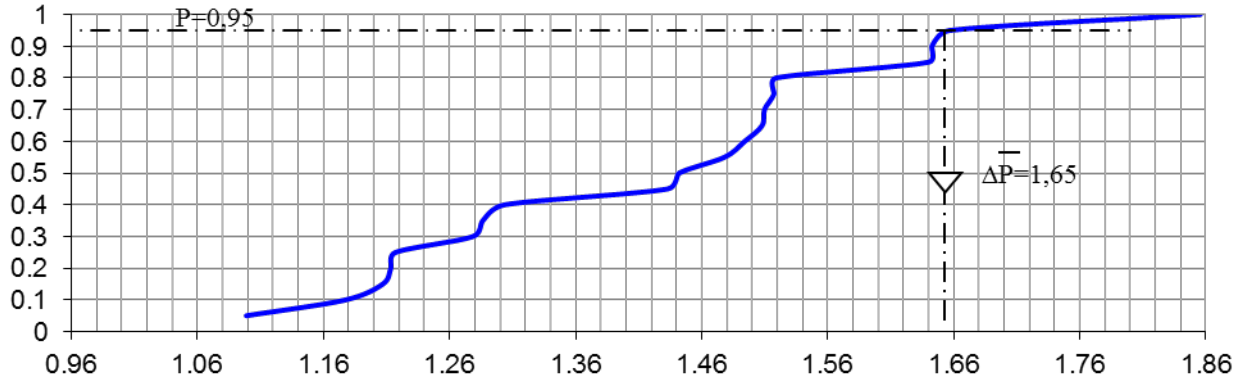




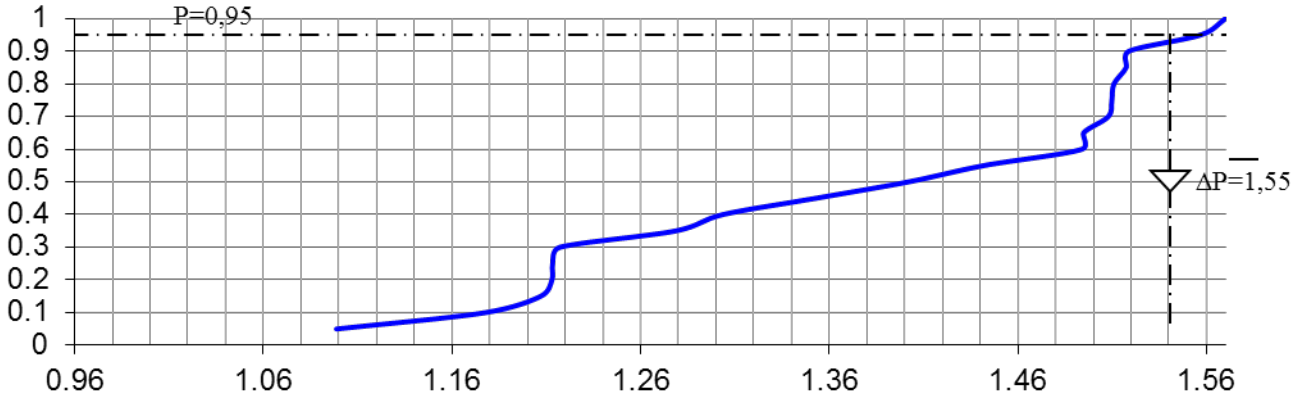
Before regulatory **After regulatory**

POWER DISTRIBUTION FUNCTIONS OF THE POWER LOSSES FUNCTION OF LOSSES

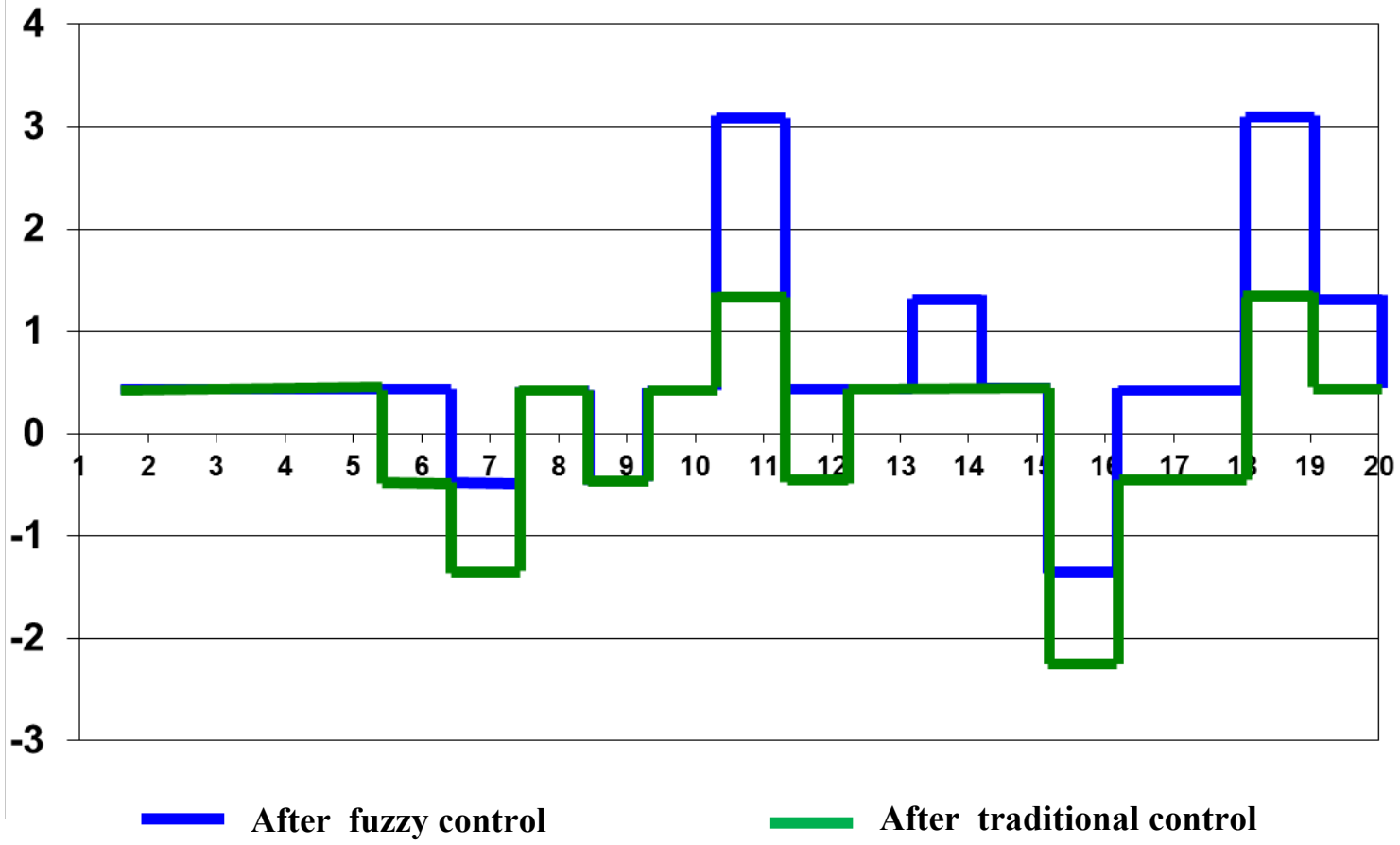
Before fuzzy control



After fuzzy control



UNDER LOAD TAP CHANGER'S DIAGRAM



TERMS OF FUZZY SETS

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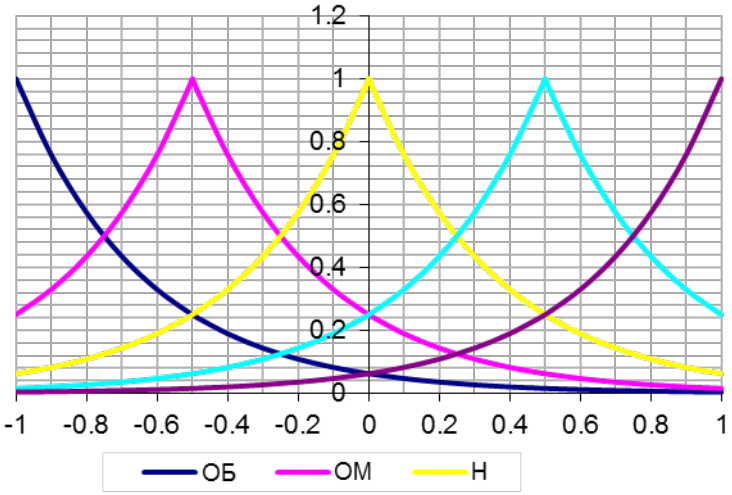
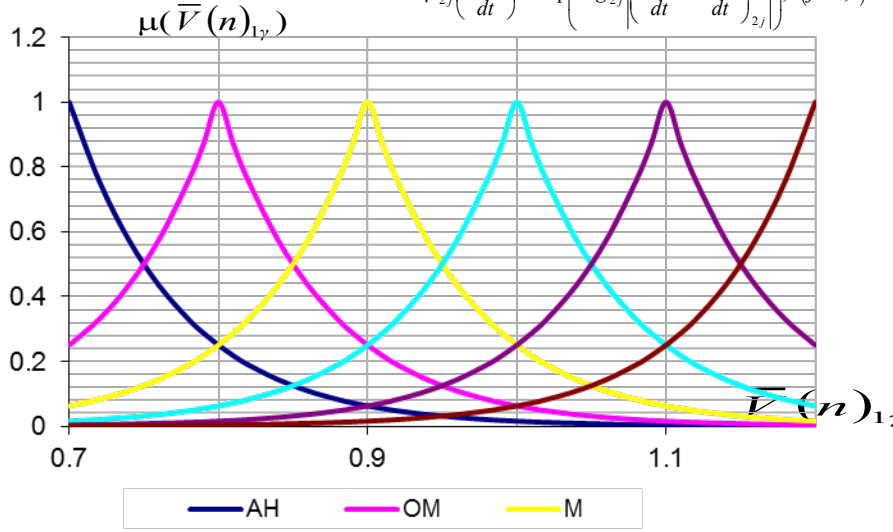
$E_{11} = CV$	(voltage catastrophe)	$\triangleq\left(\frac{U}{U_n}, \mu_{11}\left(\frac{U}{U_n}\right)\right)$	Voltage
$E_{12} = VS$	(very small)	$\triangleq\left(\frac{U}{U_n}, \mu_{12}\left(\frac{U}{U_n}\right)\right)$	
$E_{13} = S$	(small)	$\triangleq\left(\frac{U}{U_n}, \mu_{13}\left(\frac{U}{U_n}\right)\right)$	
$E_{14} = N$	(normal)	$\triangleq\left(\frac{U}{U_n}, \mu_{14}\left(\frac{U}{U_n}\right)\right)$	
$E_{15} = B$	(big)	$\triangleq\left(\frac{U}{U_n}, \mu_{15}\left(\frac{U}{U_n}\right)\right)$	
$E_{16} = VB$	(very big)	$\triangleq\left(\frac{U}{U_n}, \mu_{15}\left(\frac{U}{U_n}\right)\right)$	
$E_{21} = NB$	(negative big)	$\triangleq\left(\frac{d\Delta u}{dt}, \mu_{21}\left(\frac{d\Delta u}{dt}\right)\right)$	Dynamics
$E_{22} = NS$	(negative small)	$\triangleq\left(\frac{d\Delta u}{dt}, \mu_{22}\left(\frac{d\Delta u}{dt}\right)\right)$	
$E_{23} = Z$	(zero)	$\triangleq\left(\frac{d\Delta u}{dt}, \mu_{23}\left(\frac{d\Delta u}{dt}\right)\right)$	
$E_{24} = PS$	(positive small)	$\triangleq\left(\frac{d\Delta u}{dt}, \mu_{24}\left(\frac{d\Delta u}{dt}\right)\right)$	
$E_{25} = PB$	(positive big)	$\triangleq\left(\frac{d\Delta u}{dt}, \mu_{25}\left(\frac{d\Delta u}{dt}\right)\right)$	
$V_{11} = ND$	(negative direction)	$\triangleq(V, \mu_{11}(V(n)))$	Direction
$V_{12} = ST$	(stop)	$\triangleq(V, \mu_{12}(V(n)))$	
$V_{13} = PD$	(positive direction)	$\triangleq(V, \mu_{13}(V(n)))$	

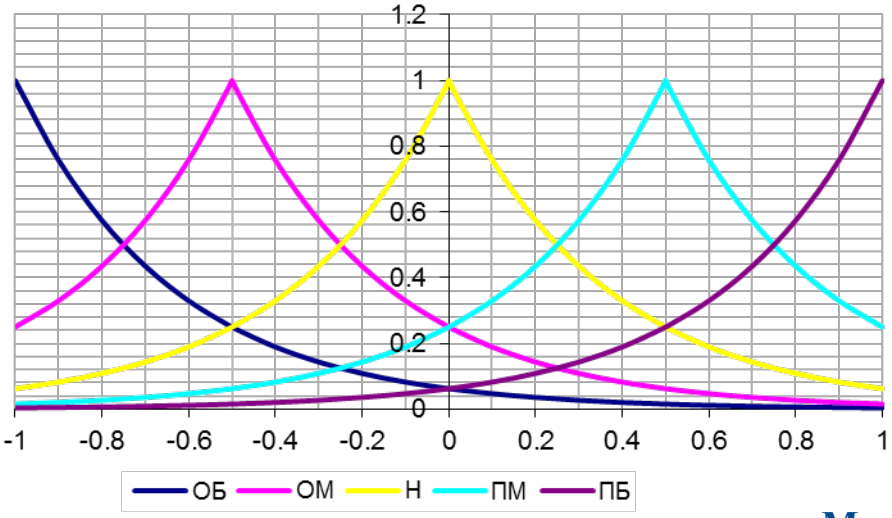
MF OF “VOLTAGE”, “DYNAMICS” “DIRECTION”

$$\mu_{1i}(U/U_n)=\exp\left(-g_{1i}\left|\left(\frac{U}{U_n}\right)-\left(\frac{\overline{U}}{U_n}\right)_{1i}\right|\right),\ \left(i=\overline{1,6}\right)$$



$$\mu_{2j}\left(\frac{d\Delta u}{dt}\right)=\exp\left(-g_{2j}\left|\left(\frac{d\Delta u}{dt}-\frac{\overline{d\Delta u}}{dt}\right)_{2j}\right|\right),\ \left(j=\overline{1,3}\right)$$





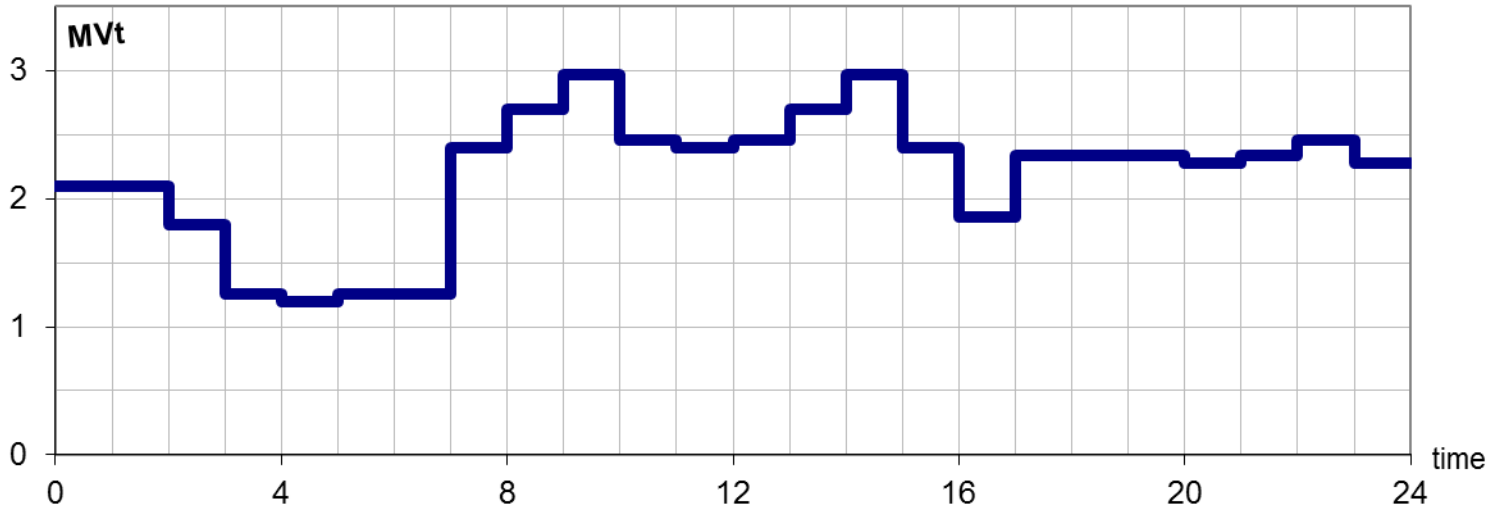
$$\mu_{3\gamma}(V(n))=\exp\left(-g_{3\gamma}\left|V(n)-\overline{V(n)_{3\gamma}}\right|\right)\ \left(\gamma=\overline{1,3}\right)$$

LINGUISTIC TABLE FOR FUZZY REGULATOR RULES

U, dU/dt	CV	VS	S	N	B	VB
NB	ST	ST	PD	ST	ST	ND
NS	ST	PD	PD	ST	ST	ND
Z	ST	PD	PD	ST	ND	ND
PS	ST	PD	ST	ST	ND	ND
PB	ST	PD	ST	ST	ND	ND

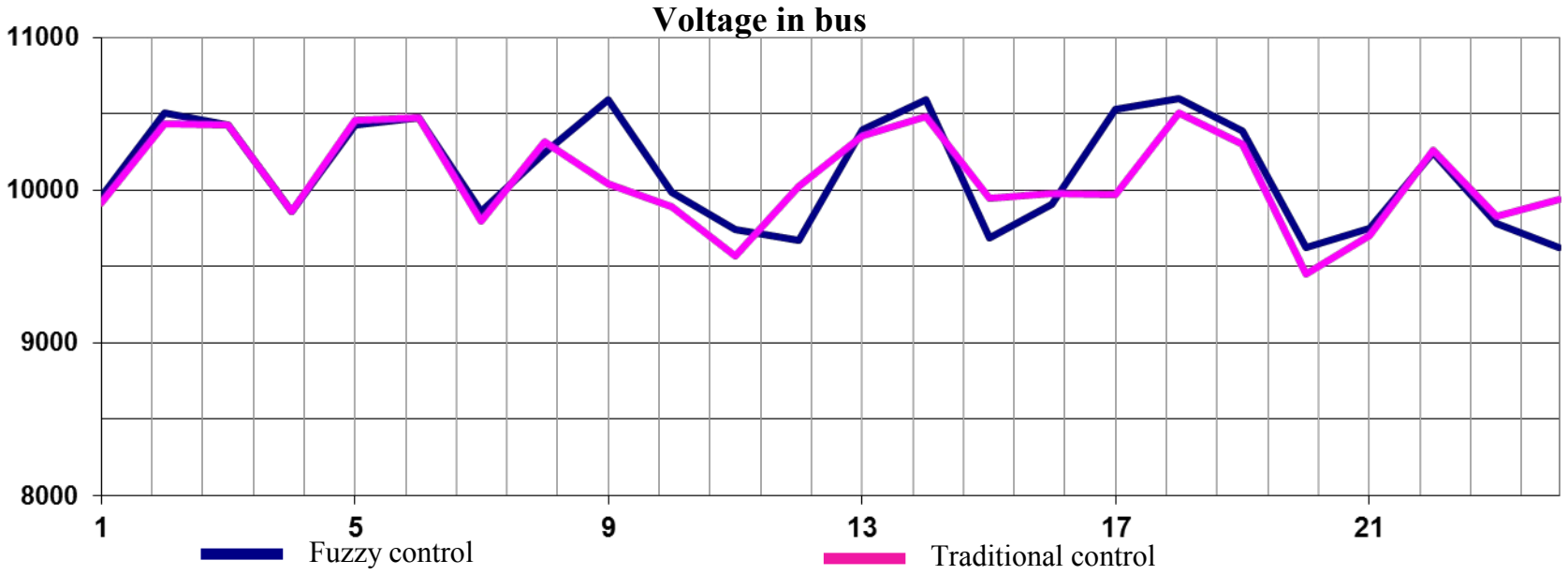
TYPICAL LOAD AND VOLTAGE CURVES

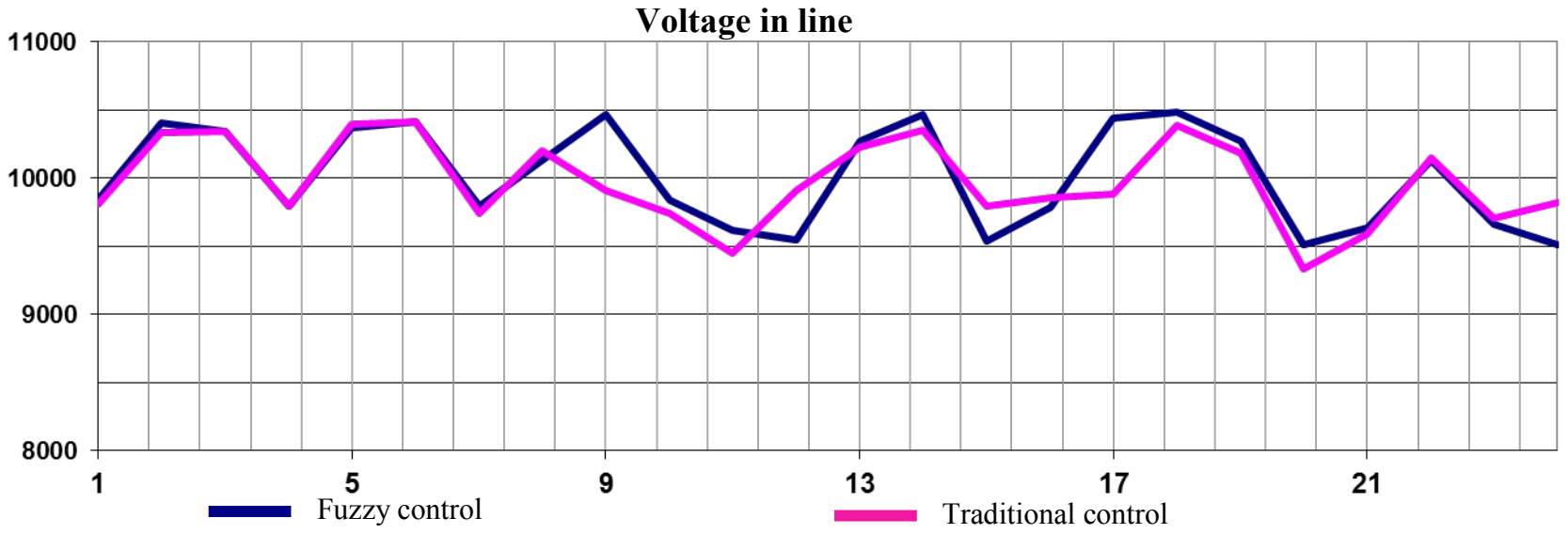
Load graphic



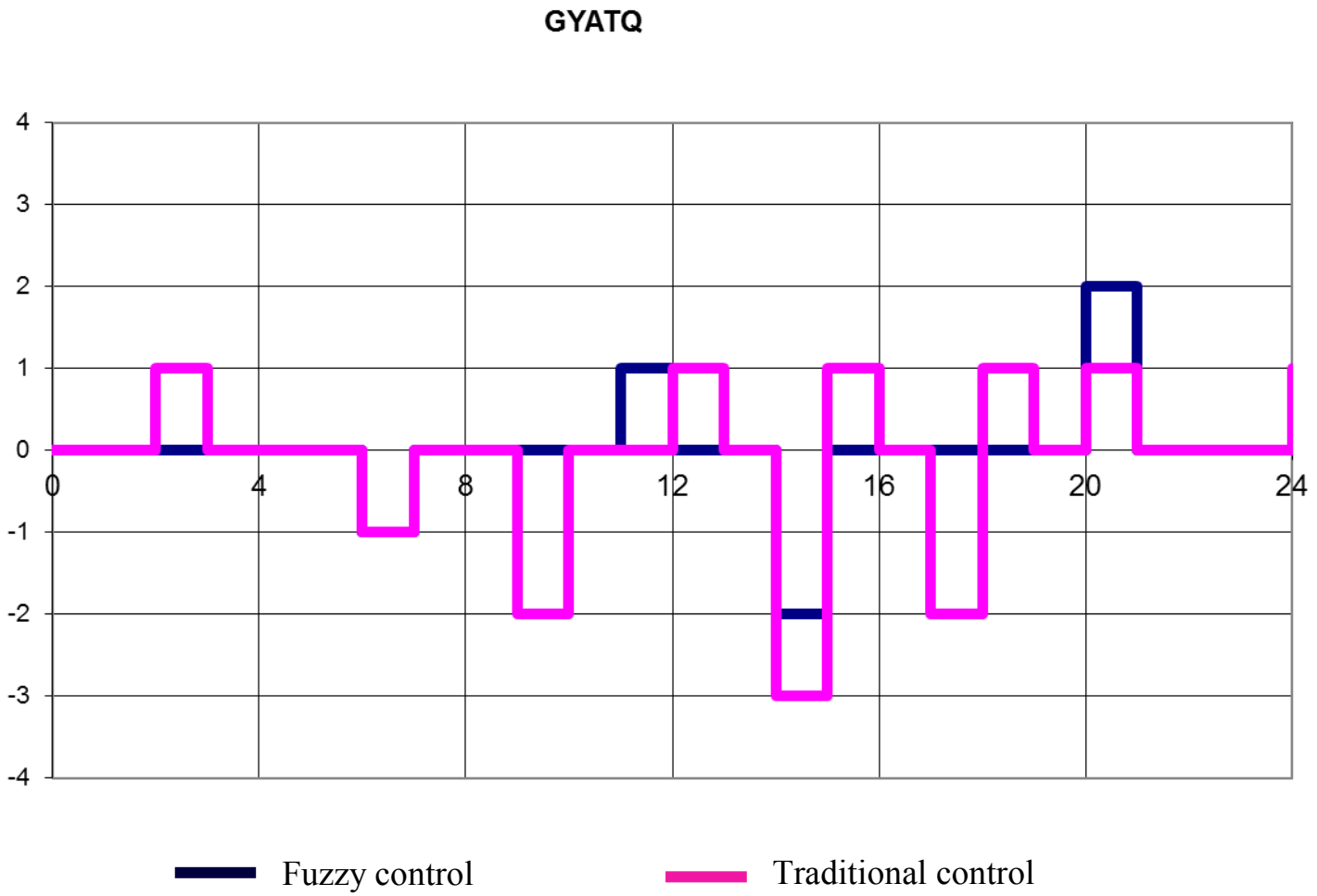
Voltage in bus

COMPARATIVE VOLTAGE CURVES





WORKING DIAGRAMS OF ULTC



CONCLUSION

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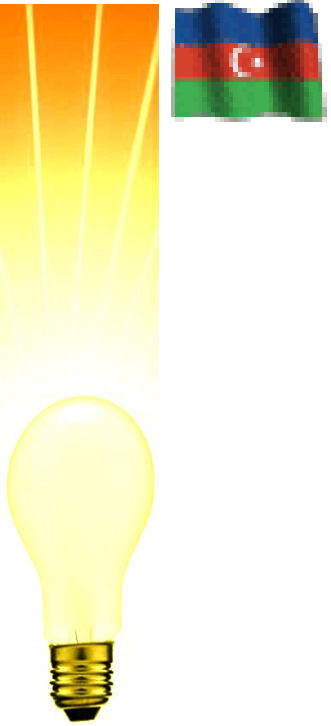
- Numerous bibliografy reviews were conducted about intellectual management of regime parameters in the power networks and advantages of fuzzy-management algorithms were determined in the uncertainty case of initial information compared with traditional management.
- Effective management on the basis of fuzzy-regulator and intellectual equipment were developed by using artificial methods like fuzzy-sets theory of voltage regime in the distributive electrical networks and fuzzy-logic.
- Conducted accounts on the base of suggested imitation system of automatic management according to computer modeling algorithm under explored typical electric network indicated reduction of power loss as a result of fuzzy-management compared with traditional-management.
- On the basis of the purposed automatic device regulation becomes more efficient, number of electric circuit changes decreases, service life of ULTC increases and the probability of its rejection decreases.



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THANK YOU FOR YOUR ATTENTİON